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VOLUME 7 NO. 4



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F.M. Signal Generator TF 2006 is another "first" in the field of wide-range solid-state signal generators. Based on separate high Q resonant-line transistor oscillators, this instrument provides wide deviation f.m. on highly stable carriers up to 1 GHz. Rigid mechanical construction ensures that the precision oscillators have very low drift and microphony. Automatic levelling maintains constant r.f. output over the entire carrier frequency range, which extends down to 4 MHz, and accurate step attenuators offer a dynamic range of 120 db. Electrical fine tuning and f.m. may be simultaneously applied by the drive circuitry. As a result of their electrical relationship within the instrument f.m. as well as the fine tuning may be adjusted to a higher accuracy against the comprehensive crystal calibrator. This oven-controlled calibrator indicates carrier frequencies by meter nulls at 10, 1 or 0.1 MHz intervals and therefore provides almost 10,000 check points of the carrier frequency.

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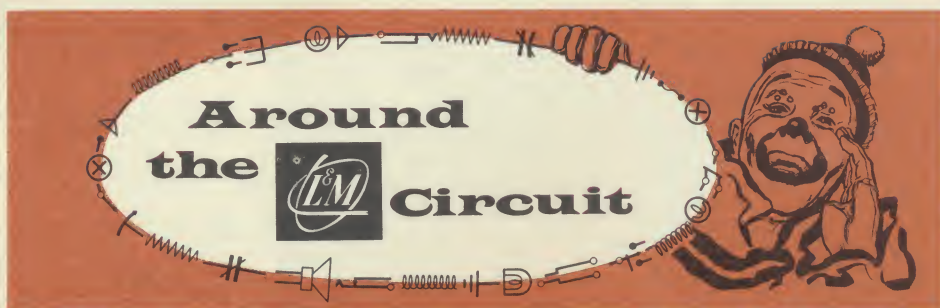
Has your company had an in-plant show?

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It says here in fine print that we at **L & M** are all refreshed and anxious and raring to go so that we may serve our customers all the better this fall. Why? We have all returned from vacation and we have no thoughts in our heads other than work - it says here!

Len Blakely deviated from his usual vacation in the Maine woods. Instead of spending two weeks, he spent three. **Bill Drobile** and his family went to California on a combination vacation and business trip. His trip coincided with the WESCON Show and he swears that he had actually visited the show. For his vacation, "**Ruby**" **Rubenstein** spent a week at the Jersey Shore basking in the sun with his lovely wife and two children. **Marty Silver** also had a variation on this year's vacation. Instead of being fog bound on the coast of Massachusetts, he was fog bound in Nantucket. **Darlene Farrell** of our New Jersey office spent her

vacation at home practicing to be an auto mechanic. If you need any work done, call **L & M** and ask for **Darlene**. **Olga Giannelli** of our New Jersey office vacationed at the Jersey Shore and we understand even went surfing. **Jo Algera** of our New Jersey office visited the Thousand Islands with her family. The trip was beautiful and **Jo** would like to repeat it again next year. **Irene Singlar** of our Andalusia office spent two weeks on the Jersey Shore with her family. We here at **L & M** hope that our readers enjoyed their vacations as much as we did - better luck next year **Darlene**.

We are happy to announce that **Carl McCallus** has been appointed Sales Manager for the Assembly and Automation Systems of **Hughes Aircraft Co., Industrial Systems Division**. We have all met **Carl** at **L & M** and have enjoyed visiting customers with him and discussing the **Hughes** Wire Laying Systems.



CARL C. McCALLUS

Micom, Inc. has added **Dan Connolly** to their staff as the Eastern Field Engineer. **Dan** has a long experience with Recording and Magnetic Tape Systems and will be invaluable to us and our customers with his technical support and customer service.

Bob Kennedy, Sales Manager, for the **James G. Biddle Company** announced the joining to their staff of **John L. Hayes**. **Jack** was Manager of Sales and Service for **Leeds & Northrup** in Eastern Canada. At present **Jack** will be spending full time on the Precision Line of test equipment and then subsequently will devote efforts to the **West German** line of **Hartmann & Braum**.



It is that point in time again when we must take leave of vacations and return to scheduling in-plant shows, demonstrations and technical sessions. By this we do not infer that nothing exciting has happened this summer. As a matter of fact, we even had a show on July 3rd at **Grumman Aircraft Engineering Corp.** one day before the long weekend. Our spring and summer schedule has been heavy.

We had a show in **ITT**, Nutley, New Jersey. This show was conducted the end of May and included

in the **Hi-Wire** column are a number of pictures taken during this show. We must give credit to **Charlie Thomas** and **Sam Silverman** of the Instrument Department for their very kind co-operation in helping us to organize a very successful show.

Late in June, **L & M** and its Principals gave an equipment in-plant demonstration at **Queensborough Community College** in Bayside, Queens. Attending this show were some twenty-five teachers and professors from the greater New York area. A good majority of the equip-



Brian Whitlock of Quan-Tech Labs, demonstrating the Model 318 Impulse and Distribution Analyzer to Charlie Thomas of ITT.

ment displayed was very highly accepted for use in the educational field. Our sincere thanks to **Gabe Kousouru** for his hospitality.

With no grass growing under our feet, one day before the big July 4th weekend we hooked our station wagons in series and headed our show to Plant 38 at the **Grumman Aircraft Engineering Complex**. We were very fortunate to have **John Watson** from U.K. answer questions

(Continued on page 7)

THEORETICALLY SPEAKING...

$$\text{TRANSFER FUNCTION} = \frac{\text{RESPONSE}(e_o)}{\text{EXCITATION}(e_i)} = \frac{B_0 + B_1 \frac{d(f_1)}{dt} + B_2 \frac{d^2(f_1)}{dt^2} \dots B_n \frac{d^n(f_1)}{dt^n}}{A_0 + A_1 \frac{d(f_2)}{dt} + A_2 \frac{d^2(f_2)}{dt^2} \dots A_n \frac{d^n(f_2)}{dt^n}}$$

PRACTICALLY SPEAKING...

measure dynamic performance of ...

- Control Systems
- Components
- Process Controls
- Vibration
- Impedance
- Automobile Suspension Design
- Autopilot Design and Test
- Radar Scanner Control
- Fuel Flow in Engines & Turbines
- Control Surfaces in Aircraft

with the NEW SOLARTRON DIGITAL TRANSFER FUNCTION ANALYZER



These are only a few of many thousands of applications where dynamic analysis directly demonstrates behavior in quantitative terms. The Solartron Transfer Function Analyzer contains a digital oscillator and digital correlator covering the frequency range of 0.00001 Hz to 480 Hz. It provides direct reading outputs of amplitude and phase in Cartesian, Polar and Log Polar coordinates. The correlation process by which the output signal from the system under test is resolved, gives a high degree of noise and harmonic rejection. Resolution and accuracy are high, typically $\pm 0.5\%$ of reading, $\pm 0.1\%$ full scale on amplitude and ± 10 minutes of arc at full scale phase.

ACCESSORIES

Modulator/Demodulator . . . for carrier frequency from 50 Hz to 10 KHz with a sensitivity of 10 μ v.

Mechanical Reference Synchronizer . . . provides automatic frequency and phase locking to external periodic signals, operates with pneumatic, mechanical or hydraulic systems and offers harmonic analysis capability.

AVAILABLE UPON REQUEST

APPLICATION/SPECIFICATION DATA . . . includes principles of operation, design features, specifications, accessories, method of operation and detailed applications from process control to material analysis.



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FOR FAST, AUTOMATIC TRANSISTOR TESTS!!

**THE MODEL PB-1 PERFORMS UP
TO 10 TESTS IN ANY SEQUENCE
IN LESS THAN 1 SECOND!!**

For incoming inspection . . . in the lab . . . in production . . . Baird-Atomic's new *Model PB-1 Automatic Transistor Test Set* measures DC parameters of NPN and PNP transistors on a go/no-go basis at bias levels up to 250 volts, 300 ma!

Most important, the Model PB-1 can perform up to 10 tests in any sequence in less than 1 second! Pulse drive techniques permit direct measurement of transistor DC parameters at far greater power levels than transistors could survive employing ordinary measurements!

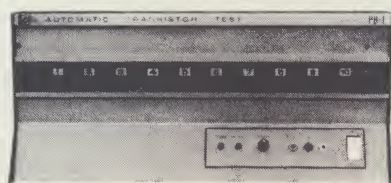
Further, many types of diodes and SCR's can also be tested on the Model PB-1. V_F , I_R , and V_Z are evaluated on a go/no-go basis with the same techniques as those used for transistors!

MODEL PB-1/SPECIFICATIONS

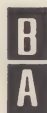
- **ACCURACY:** $\pm 2\%$ OF READING ASSUMING TEST CARD CALCULATIONS FOR RESISTANCE VALUES ARE WITHIN 0.2%
- **TEST PULSE:** 300 μ SEC WIDE WITH A 1% DUTY CYCLE
- **DC PARAMETERS:** NPN-PNP TRANSISTOR MEASUREMENTS; ALL TYPES OF DIODES (WITHIN VOLTAGE AND CURRENT LIMITATIONS)
- **POWER:** 115 VAC, 50/60 CPS, 2 AMPS.
- **SIZE:** 8½" H x 19" W x 16" D

Descriptive literature is immediately available — we cordially invite your inquiries.

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TEST SET



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HUGHES SEMI-AUTOMATIC SOLDER SYSTEM

A new reflow soldering system for "all-lead" soldering of integrated circuit packages has been introduced by **Hughes Aircraft Company**.

The new system, Model HPS-120, utilizes the unique loading "nests" feature of the **Hughes VTA-67** soldering head for positioning the IC package under the heater bars. It also features many of the capabilities of the HPS-200 fully-automatic place and solder system, with the exception of automatic feed and actuation.



The HPS-120 has an X-Y positioning table with stylus and detent positioning and a 12" x 12" travel. Twelve-inch throat depth accommodates large boards, and the heater bars, which are adjustable to 1-7/8", are independently suspended to adjust to uneven printed circuits.

After being positioned by the loading "nest", the device being soldered is held in place by a vacuum pickup. A special feature is a desolder cycle for removal of defective or misplaced devices from the PC board.

A special microscope mounting bracket allows the operator to view the IC during the reflow as well as after reflow for inspection.

The complete system includes, in addition to the soldering head assembly and the X-Y positioning apparatus, the **Hughes MCW-550** constant voltage power supply, a stereo-zoom binocular microscope, plus mounting and other accessories. Basic price of the system is \$5,275.



To save you some time, The Metal Stickers at Hughes have developed a fully mechanized reflow solder station that eliminates fumbling with I.C. packages.

The HPS-200 picks them up.

Places them on your board.

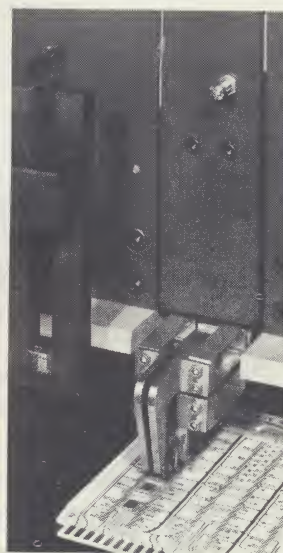
And solders them. All in eight seconds. Or less!

Flat packs are magazine fed. But gently, so the leads aren't mangled. Like they often are by fingers.

It gives you assembly-time savings to go with the packaging density and other advantages afforded by flat packs. Or if you prefer the lower cost of DIP's, let The Metal Stickers show you how to save the cost of board drilling and inserting.

The pickup head incorporates a vacuum chuck for holding the pack and heater bars for reflow soldering all the leads simultaneously. The HPS-200 system will accommodate flat packs, dual-in-line packages and hybrids up to 1" square. The standard X-Y table travels a full 12" x 12".

Take a minute to write to The Metal Stickers. They'll give it back to you a hundred times. Write to 2020 Oceanside Blvd., Oceanside, Calif. 92054.



HUGHES

HUGHES AIRCRAFT COMPANY
HUGHES WELDERS



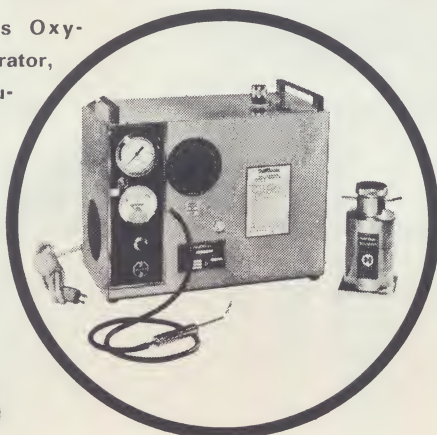
HAVE YOU SEEN

ordinary water provide a 6000° flame*

that will weld, solder, anneal, cut, and drill?

This is the Henes Oxy-Hydrogen Flame Generator, an invaluable instrument for the laboratory—a profitable tool in production.

**consider
these
applications**



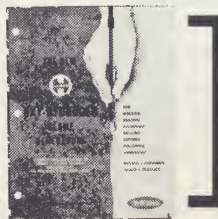
- **WELD** resistance wire to copper • **BRAZE** contacts to relay blades • **FUSE** tungsten to nickel • **SOLDER** relay cans to headers • **STRIP** wires of teflon, nylon or enamel insulation • **ANNEAL** spring wires and blades • **DRILL** holes in quartz, ceramic, tungsten • **WELD** chromel and alumel wires • **SOLDER** broken welds in electronic modules • **FUSE** glass and quartz parts • **SOLDER** coaxial connectors

Or perform any other operation where high heat in a concentrated area is required. Flame size is adjustable from pin-point to pencil size.

Five models available from \$250.00 to \$725.00

***The Henes Oxy-hydrogen Flame Generator actually uses distilled water as fuel, disassociating it to hydrogen and oxygen in ideal proportions for combustion.**

Interesting? Then write for detailed brochure. The Oxy-hydrogen Flame Generator may be just the right tool for your application.



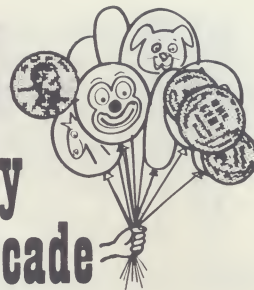
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Tel: (602) 275-4126



**Penny
Arcade**



The following instruments are being offered for sale with standard new equipment warranties. Equipment may be slightly used or may have been superseded by a later model. Complete data will be furnished upon request.

● **HUGHES AIRCRAFT COMPANY**
Model HRW-102 100 w/s Power Supply, solid state with dual pulse selection. New with blemished cabinets. 5 only. Original Price \$750. Sale Price **\$575.**

● **HUGHES AIRCRAFT COMPANY**
Model VTW-29C 40 w/s Power Supply, S/N 471. New with blemished cabinet. 1 only. Original Price \$465. Sale Price **\$400.**

● **HUGHES AIRCRAFT COMPANY**
VTA-49 Pressure Gage, 25 # maximum, Blemished. 1 only. Original Price \$150. Sale Price **\$25.**

● **HUGHES AIRCRAFT COMPANY**
Model VTA-50 Pressure Gage, 50# maximum. New-carries no warranty. 8 only. Original Price \$150. Sale Price **\$25.**

● **HUGHES AIRCRAFT COMPANY**
Model VTA-51 Pressure Gage, 100# maximum. New-carries no warranty. 19 Only. Original Price \$150. Sale Price **\$25.**

● **BAIRD-ATOMIC, INC.**
Model KP-3 "h" Parameter Test Set. Demonstrator, 1 only. Like new. Original Price \$1095. Sale Price **\$995.**

● **HUGHES AIRCRAFT COMPANY**
Model VTW-31B-MS 200 w/s Power Supply with SCR. 5 only. Original Price \$895. Sale Price **\$650.**

● **MARCONI INSTRUMENTS**
Model 1041C VTVM, 20 Hz to 1500 MHz. Demonstrators, 2 only. Original Price \$395. Sale Price **\$185.**

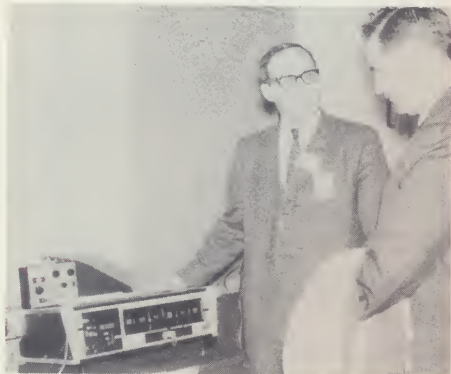
● **MARCONI INSTRUMENTS**
Model 2331 Distortion Factor Meter, 20 Hz to 20 HKz. Demonstrators, 2 only. Original Price \$795. Sale Price **\$495.**

● **MARCONI INSTRUMENTS**
Model 2330 Wave Analyzer, 20Hz to 50KHz. Demonstrators, 2 only. Original Price \$1895. Sale Price **\$650.**

● **HUGHES AIRCRAFT COMPANY**
VTW-31B 200 w/s Power Supply. 5 demonstrators. Original Price \$775. Sale Price **\$650.**



William Ing of ITT and L. Presutto of Marconi Instruments discussing the Marconi Model 2702 Inductance Analyzer.



Jim Kingsberg of James G. Biddle demonstrating the Mentor to John Hendrickson of ITT.



Marty Silver of L & M, N. J., discussing the "Megger" with Herb Baasch of ITT.

about the **Marconi-Solartron** Transfer Function Analyzer. The show was well accepted by the **Grumman** engineers and their interests and questions were varied. We would again like to take this opportunity to thank **Arthur Friedman** of Plant 4 for his aid and cooperation in helping us set-up this show.

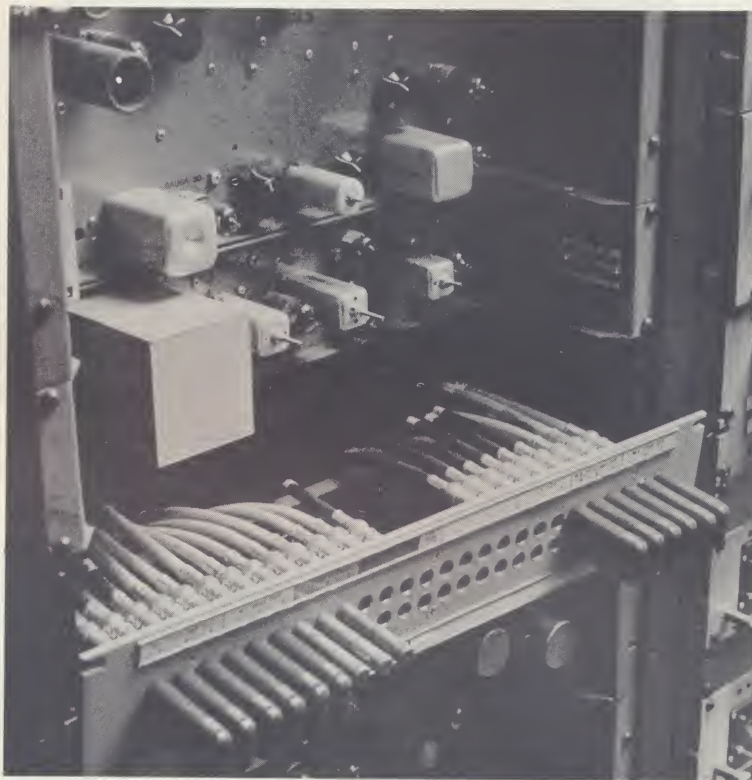


Ray G. Mummert of Sylvania and Bill Drobile of L & M, Andalusia performing welds on the Hughes Microcircuit Welder.

(Continued on page13)

NOW

A NEW 75 OHM PATCHING SYSTEM



A major break-through in 75 ohm patch jacks, plugs and accessories.

The new line is designated with a "U" in front of the components listed in the current T7 Catalog. Each part will be compatible for use with the Western Electric version with a .090 pin or the RCA version with a .070 pin.

The custom 75 ohm "U" series eliminates the troublesome discontinuities that exist when using 50 ohm connectors in 75 ohm systems. Measurements indicate return losses on the order of 35 db (about 1.05:1 VSWR), at 60 MHz, impedance 75 ohm $\pm$ 2 ohms using 75 ohm cable such as RG59/A, Belden 8281, or 8279 Western Electric 724/728.

Standard and miniaturized patching systems are available in the new line, part of which is illustrated in the T7 Catalog (pages 18 and 19). Also included in the line are modified "BNC" and "TNC" connectors that are 75 ohms impedance as measured in time domain reflectometer tests.

In order to prevent mismatching, a standard 50 ohm BNC with the 75 ohm BNC, the smaller diameter male pin is installed in the receptacle as opposed to the plug.

As a leader in the field of patching and switching equipment, we at Trompeter Electronics are convinced that these latest developments provide one of the answers to the "sticky" problem of maintaining an impedance match thru the cable and connectors, thereby providing reasonable VSWR and return loss characteristics.



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NEW FROM BIDDLE A MULTIPURPOSE MENTOR[®]

Performs the Work of Three Instruments in One

- ① For Limit Testing ② For Comparison and Adjustment ③ For Precision Measurement of A-C or D-C Voltage, Resistance, or Ratio

This new multipurpose instrument gives you the stability and accuracy of our regular Mentor Instruments, plus the unique ability to perform setting-up and calibrating functions at maximum speeds with ease.

Its three-in-one facility gives you the following advantages: Use it as a limit tester with "Low"—"Go"—"High" display. Use it as a semi or fully automatic system to guide the adjustment of input parameters to preset target values or limits with "Go" display. Or, use it as an error-free, logic-assisted, five-digit multimeter.

AVAILABLE IN FOUR MODELS

- #804 for D-C voltage tests
- #805 for D-C volts and millivolts/ohms/ratio
- #904 for A-C/D-C volts
- #905 for A-C/D-C volts and millivolts/ohms/ratio

These instruments have a basic accuracy for D-C voltages of 0.002% (20ppm) of reading (ASA Reference conditions); state of art accuracies in other parameters.

For prompt, personal attention, we suggest you contact Mr. W. J. Kingsberg at James G. Biddle Co. for the most up-to-date information and the name of the nearest qualified representative who can serve you.



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819

ELECTRONIC MEASUREMENTS USING STATISTICAL TECHNIQUES

By
SIDNEY L.
SILVER

Many physical phenomena produce nonperiodic, random signals that must be analyzed by a statistical study of their average characteristics. Examples include thermal and shot noise, static interference, irregular mechanical stresses, or vibration. Techniques used are probability density, distribution correlation, spectral analysis.

IN many branches of applied science and engineering, there occur problems involving the measurement of physical quantities whose solution depends upon the proper interpretation of the relative amplitude, phase, and frequency characteristics of complex waveforms. Harmonic functions, for example, produce data which may be separated into simple periodic waveshapes in order to determine the various frequency components and their energy distribution. Such quantities are said to be "deterministic" since their instantaneous values can easily be predicted as a function of time.

In practice, however, many physical phenomena produce non-periodic or random information, which can best be defined in statistical terms. These quantities are described as "probabilistic" since their instantaneous amplitudes cannot be predicted with complete certainty at any future period of time. Instead, they must be analyzed by making a statistical study of their average characteristics over a specific time interval.

Typical examples of measurable quantities which produce random data are temperature fluctuations in an industrial control process, noise and vibration from high-power jet and rocket engines, buffeting forces on an aircraft at gust wind velocities, acoustic pressures generated by turbulent air, motion of a structure caused by seismic excitation, stresses of a stabilized ship exposed to rough ocean waves, static interference in communications systems due to atmospheric disturbances, shot noise in a vacuum tube, and thermal noise in a resistor.

Characteristics of Random Waveforms

To demonstrate the nature of a random process, the voltage-time history of a number of random-noise generators of identical design and construction is plotted on a chart recorder (Fig. 1). For convenience, the mean value of each waveform is arbitrarily chosen to be zero. By operating all generators simultaneously the collection, or ensemble, of sample records is observed to fluctuate erratically, each waveform representing only one of many possible occurrences. Clearly each observation of the instantaneous magnitudes is a unique phenomenon, since the waveshapes never exactly recur in a finite time period. Any attempt to make a precise, detailed analysis of the fluctuations by observing previous values would be meaningless.

Theoretically a thoroughly accurate implementation of the random process would involve an infinite number of sample records over an infinite time period. In practice, however, only a finite number of noise generators need be considered, since the long-term average characteristics of the amplitude values remain unchanged by any additional noise sources. By applying statistical concepts to the measurement of these random signals, it is possible to quantitatively describe them by computing the integrated values of the waveforms over a predetermined interval of time. Some of the apparent statistical variations can then be determined and a reasonably accurate estimate of the future values easily obtained.

If the statistical properties of an ensemble (of sufficient

length) do not vary with time, the ensemble is said to be stationary. This implies that the mean value, the amplitude distribution about the mean value, the number of peaks per unit time, and the predominant frequencies, if any, of the collection of sample records is the same. In this article, reference will be made only to those stationary random phenomena with *ergodic* properties, *i.e.*, where the time average of a single sample record is equal to the corresponding ensemble average value, thus leading to the same statistical results. Fortunately, most statistical phenomena are generally ergodic so that such random data can be properly measured from a single sample record.

In the electronic measurement of random information, there are three domains in which the statistical parameters may be processed: amplitude domain (probability density and distribution), time domain (correlation), and frequency domain (spectral analysis). Any of these can be implemented through analog or digital techniques.

Amplitude Domain Measurement

An important means of characterizing random data in the amplitude domain is the probability density function (PDF), which describes the probability that the waveform

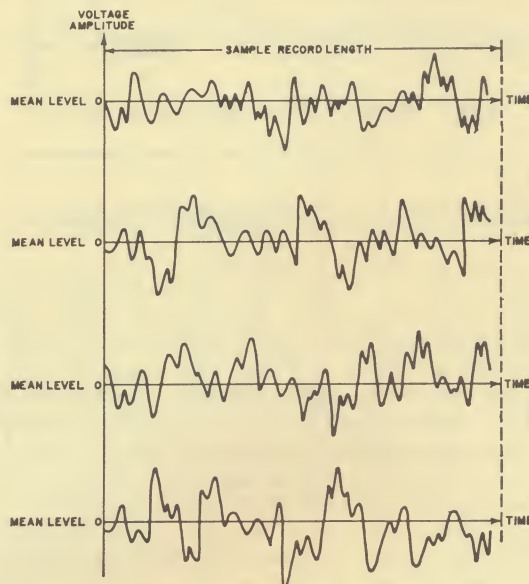


Fig. 1. Volts-time history of random data from 4 noise generators.

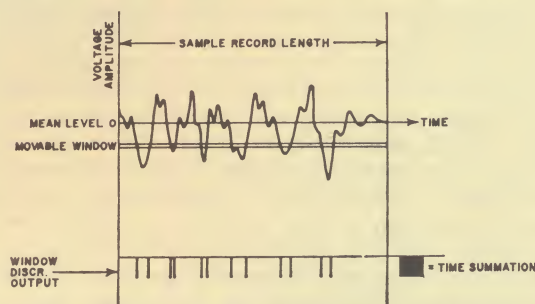


Fig. 2. A graphic determination of probability density function.

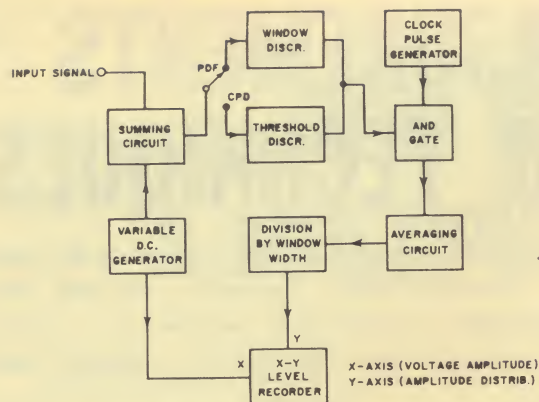


Fig. 3. Amplitude distribution analyzer measures the probability density and cumulative probability distribution

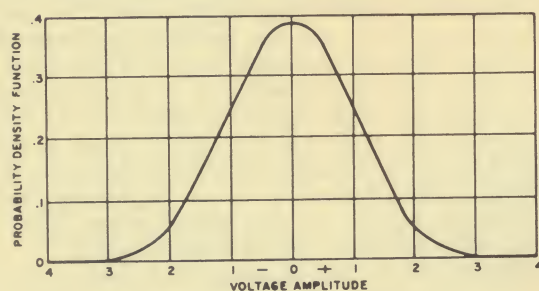


Fig. 4. A normal probability density function curve.

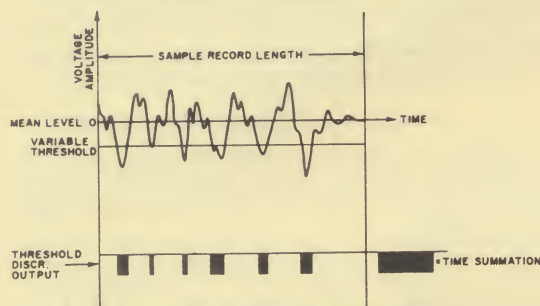


Fig. 5. Evaluation of cumulative probability distribution.

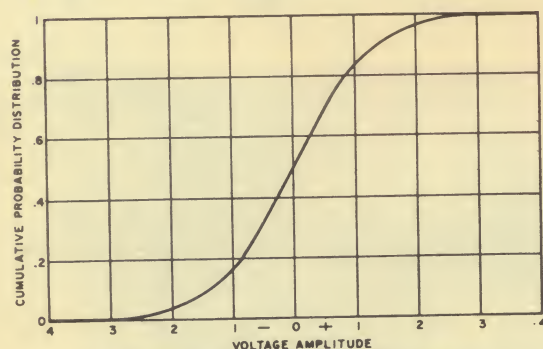


Fig. 6. Cumulative probability distribution function curve.

amplitude will assume a value within some specified range of values at any interval of time.

Initially, the quantity to be analyzed is picked up by a suitable transducer which converts the original signal into electrical form. The computation of the PDF is most conveniently accomplished by recording a sample of the signal on a magnetic tape loop. During the playback mode, the signal is continuously compared with a reference level, or "window", discriminator which "slices" the sample record into a very narrow amplitude range (Fig. 2), thus allowing only that portion of the signal to pass through the system. The signal waveform is then integrated over the time the signal spends within the amplitude window. At the end of each tape revolution, the integrated signal is plotted and the window voltage is moved one incremental step before the next integration cycle begins. This process continues

until the scanning band sweeps the entire amplitude range of the input signal, producing a graphic representation of the amplitude distribution curve.

A functional block diagram of a typical amplitude distribution analyzer is shown in Fig. 3. In the PDF mode of operation, the input signal is mixed with a variable d.c. potential. This provides a bias voltage which allows different levels of the waveform to be sampled by the window discriminator, and simultaneously shifts the X-axis of the graphic recorder. Each time the instantaneous value of the signal falls within the limits of the window, the *and* gate opens and passes 1-MHz clock pulses to the averaging circuit. By this means, a measure of the total number of pulses passed by the window circuit is obtained, expressed as a percentage of the total number of pulses generated.

The time average may be obtained either by a true integrator (consisting of an operational amplifier with feedback capacitor), or by a low-pass RC filter which continuously smoothes the amplitude fluctuations. In general, true averaging is employed when the scanning process is accomplished in discrete steps (stepped scan), and RC averaging employed when a continuous scan sweeps the window. Finally, the required division of the average sampling time by the window width (fixed amplitude window voltage) yields the probability density function. Applying this parameter to the Y-axis of the level recorder produces a plot of PDF vs voltage amplitude.

Fig. 4 shows a normal, or "Gaussian", PDF curve which is frequently encountered in random data measurement. Here the higher portions of the symmetrical curve correspond to the region where most of the input signal values occur, while the lower sections indicate values which rarely occur. The area of the curve is based on a scale of unity (or 100%), so that any given area under the curve may be expressed in terms of a percentage of all values represented by the entire curve. Thus, for example, the probability that the instantaneous amplitude values of the input lie within a range bounded by zero and +3 volts, is 50%.

An alternate method of evaluating the amplitude distribution of a random waveform is a measure of the "cumulative probability distribution" (CPD), which contains the same information as the density function but presents it in a different form. The value of the CPD function is defined as the probability that the input signal is equal to, or below, a given amplitude.

In this mode of operation, one of the two thresholds of the window discriminator shown in Fig. 3 is eliminated, thus extending the amplitude slice to include all of the magnitudes that are less than, or equal to, the remaining threshold. Initially, the reference level is set below the maximum negative value of the sample record to be examined. As the threshold voltage sweeps upward from negative to positive values (Fig. 5), an increasing portion of the input signal will lie below the reference level. By comparing the proportion of time that the signal falls below the threshold to the total sampling time, a plot of the CPD-function vs voltage amplitude is automatically produced (Fig. 6). At the completion of the scanning process, the entire signal waveform lies below the reference level and the integrated output is considered to be 100%.

The principal applications for amplitude distribution measurements include the determination of threshold levels in mechanical stress analysis, detection of non-linear structural characteristics, surface and thickness instrumentation, and testing for normality of random data.

The Domain Measurement

One of the most powerful techniques used to describe the properties of random fluctuations in the time domain is the correlation function. The correlation concept determines the extent to which a future value of a random quantity will be the same as preset value of that quantity. By establishing a measure of similarity between two wave-

forms, or by determining the influence of one signal upon another, a quantitative analysis of the degree of randomness may be obtained.

An important parameter employed in the computation of random data is the "autocorrelation function" (ACF). This quantity refers to the dependency of a random signal upon a time-shifted version of itself, and provides a convenient means of determining the presence of a periodic signal obscured in a background of random noise. To implement this process, it is necessary to delay the random signal by a variable time displacement, multiply the signal value at any instant by the value preceding the delay time, and finally average the instantaneous product value over the total time of the sample record.

Fig. 7 shows a typical ACF analyzer which operates in conjunction with a special-purpose instrumentation tape recorder. In this arrangement, a time sample of the signal to be analyzed is recorded on a magnetic tape loop, and fed to a time-delay generator to provide the necessary lag time. The variable time displacement is obtained by means of a movable playback head which automatically advances one small step for each revolution of the tape loop. Both the input and the output of the delay generator are

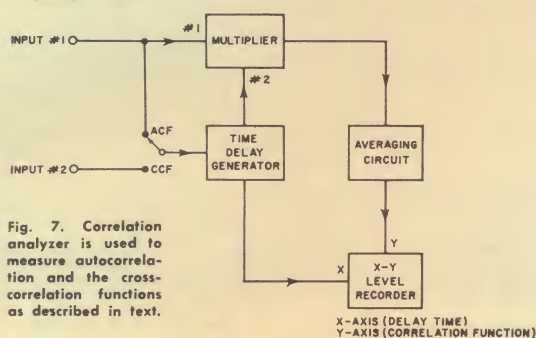


Fig. 7. Correlation analyzer is used to measure autocorrelation and the cross-correlation functions as described in text.

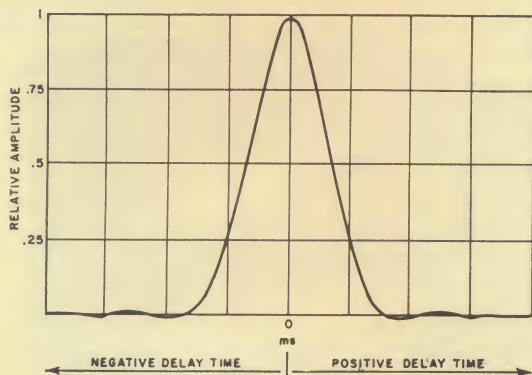


Fig. 8. Autocorrelation function of wide-band random noise.

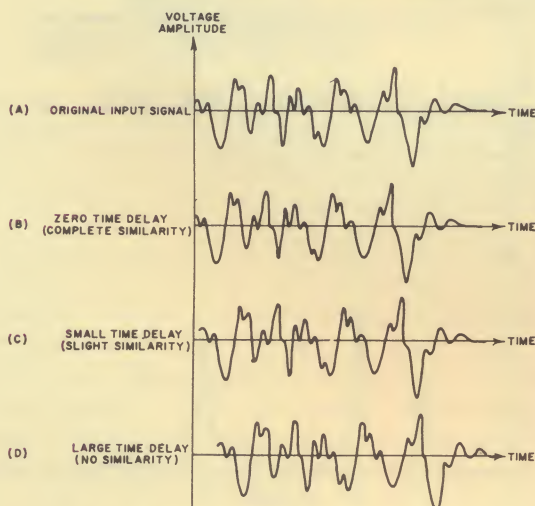


Fig. 9. Time-shifting of the sample record during autocorrelation scanning process to assess degree of similarity.

then multiplied and time-averaged so that at the end of each integration cycle, the output appears as a series of discrete points on the curve. In some instruments, correlation values are measured while the delay time is continuously varied through the time displacement of interest, so that a continuous output curve is obtained. The sample record is recirculated until the information at each time delay is completely scanned and a graph of ACF vs time displacement is plotted on the X-Y recorder.

Fig. 8 shows an ACF plot, called an "autocorrelogram", which is typical of wide-band random noise. Assuming that the curve is plotted on positive and negative delay values, the graph is observed to be a sharply peaked symmetrical pulse which reaches a maximum value at zero time delay. The pulse then diminished to very low values until the correlation function reaches zero at large time delays.

In order to interpret the form of the ACF curve, the relationship among the time-displaced versions of the input waveform is given in Fig. 9. At zero delay time, the random fluctuations applied to each input of the multiplier are in-phase. Since each positive and negative ordinate in

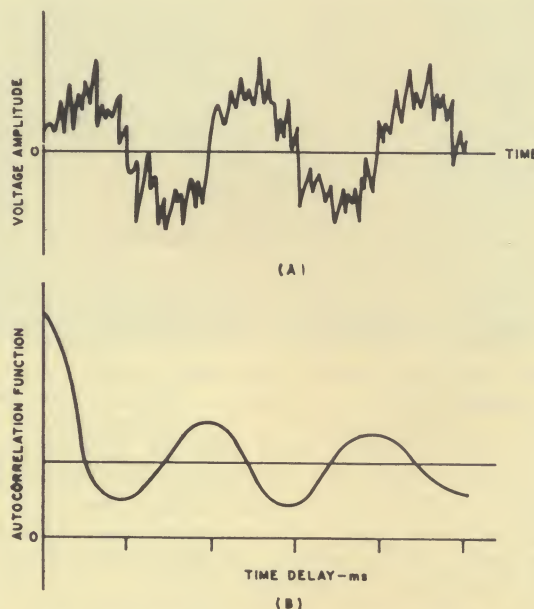


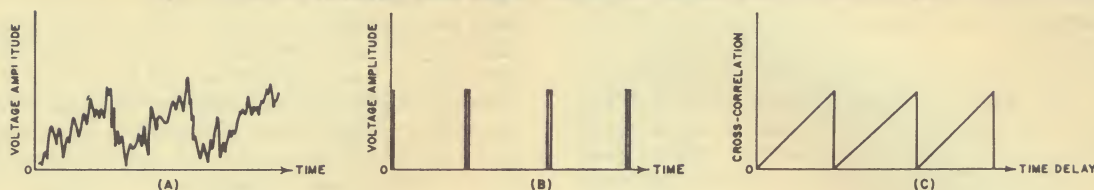
Fig. 10. (A) Voltage-time plot of sine wave immersed in noise. (B) Resulting autocorrelogram extracts the periodic component.

(A) is identical to its counterpart in (B), the product of both values contributes a positive term to the sum. As the delay time increases during the scanning process, the waveform becomes less and less related to itself in (C), until the point is reached in (D) where the similarity is completely destroyed. Now that each positive product value is offset by another negative product, the sums rapidly decrease and the ACF reading falls effectively to zero.

If a sine wave were fed to the ACF analyzer, the autocorrelogram would also be sinusoidal, having the same frequency and harmonic content as the input signal but dropping all phase information. It is reasonable to expect, therefore, that an ACF measurement of a wide-band noise record containing a hidden sine-wave component (Fig. 10A) would have some of the characteristics of both the random noise and the periodic signal. The resulting autocorrelogram in Fig. 10B indicates the peaked curve at zero delay; with the sinusoidal component persisting over all time displacements. Clearly the correlation technique makes it possible to detect and recover periodic information by greatly improving the signal-to-noise ratio (as much as 40 dB) of an incoming signal.

Now that the frequency of the periodic signal to be extracted from the random noise is known, a more powerful technique, called the "cross-correlation function" (CCF), may be applied. This is accomplished by switching the

Fig. 11. (A) Time plot of sawtooth wave in noise. (B) Time function of reference pulses. (C) Cross-correlogram.



ACF analyzer, shown in Fig. 7, to the CCF mode of operation. In this arrangement, the random signal fed to the direct input of multiplier #1 is independent of an external periodic waveform applied to the time-delay generator. Since the delayed input to the instrument is now a pure sine wave of the same frequency as the hidden periodic signal, the CCF analyzer produces a still greater improvement in signal-to-noise ratio and, in the ideal case, reduces the noise components of the signal to zero. An important advantage of this method over autocorrelation is that phase information is preserved, so that the resultant cross-correlogram is a proportional reproduction of the original time function.

Another method of detecting a signal masked by extraneous noise is indicated in Fig. 11. This technique consists of cross-correlating the obscured signal (Fig. 11A) with a series of narrow pulses (Fig. 11B) which have the same fundamental frequency as the obscured signal. The resultant CCF curve (Fig. 11C) reveals the hidden signal to be a triangular wave.

The cross-correlation technique may be employed to establish a possible "cause and effect" relationship between a disturbing sound source and a reverberant condition. In acoustic vibration problems, for example, cross-correlation is useful in determining the transmission paths and propagation velocities of a random vibration source. By placing one microphone close to the source of the disturbance and moving another microphone to different locations in sequence, a CCF computation is performed for each point. If multiple sound paths exist the cross-correlogram will contain one peak for each sound path, while unrelated disturbances will rapidly correlate to zero. The delay value at each peak corresponds to the transmit time of the transmission path, and the ordinate of each peak indicates the relative contribution of each sound source.

Frequency Domain Measurement

Since random waveforms are characterized by the relative distribution of their frequency content, the analysis of non-periodic signals may be obtained in terms of the "power spectral density" (PSD) function. This parameter describes the harmonic composition of random data in terms of the mean square, or average power distribution over the frequency spectrum. To make an analysis, it is necessary to filter the input signal and average the squared instantaneous value over the total sampling time.

In the PSD analyzer shown in Fig. 12, the data stored on a magnetic tape loop is heterodyned in the modulator by the output of a swept local oscillator. The modulator output is then fed to a highly sensitive narrow bandpass filter (with a fixed center frequency), which extracts that portion of the signal whose frequency lies within its passband. The frequency components are detected by the squaring circuit and averaged by an RC filter whose time constant is set equal to the sample record length. Where a true integrator is used for averaging, the transient produced by the tape splice is used to derive a trigger pulse in order to reset the integrator at the end of each tape loop period. The required division of the mean square value of the averaging network by the filter bandwidth may be obtained by a proper scale calibration. As the sweeping oscillator scans the frequency range of interest, the center frequency of the bandpass filter is progressively moved, and output of the

analyzer is displayed as a continuous plot of PSD function vs frequency.

In Fig. 13A, a sample voltage-time history record is shown of an undesirable random vibration, such as that produced by industrial machinery. By feeding this data into the PSD analyzer, the resultant power spectral density curve (Fig. 13B) shows how each peak level represents the signal contribution within the sample bandwidth. Since the total power distribution is equal to the entire area under the curve, the power in each of the peaks can be calculated from their individual areas. Now that the hidden components in the frequency domain are easily identified, and knowing the rotational speed of the machine parts, the disturbing vibration source can be located and eliminated.

Where the phenomena being investigated involve the analysis of two related random processes, some knowledge of the phase relationship between the two quantities is sometimes required. For example it may be necessary to determine to what degree an acoustic source of vibration is responsible for the mechanical vibration in a metallic structure. This can be accomplished by means of a "cross-spectral density" (CSD) analyzer which measures the linear relationship between the power spectral density data represented by the two sample records.

The statistical concepts discussed have been restricted to the analog measurement of stationary random data. Since the processing techniques do not, for the most part, apply to the analysis of non-stationary random waveforms (whose statistical properties change with time), more sophisticated methods must be developed to handle such data. ▲

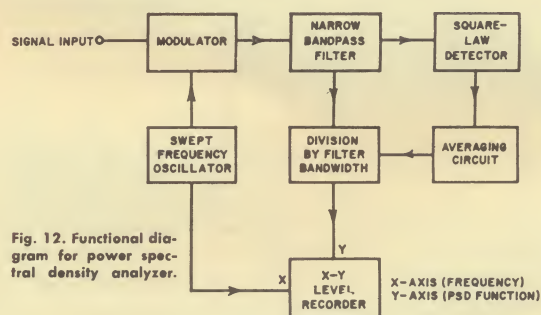


Fig. 12. Functional diagram for power spectral density analyzer.

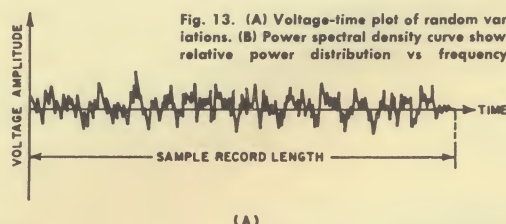
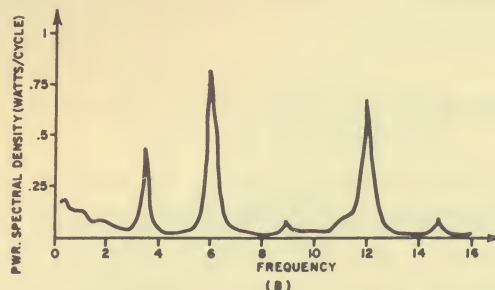
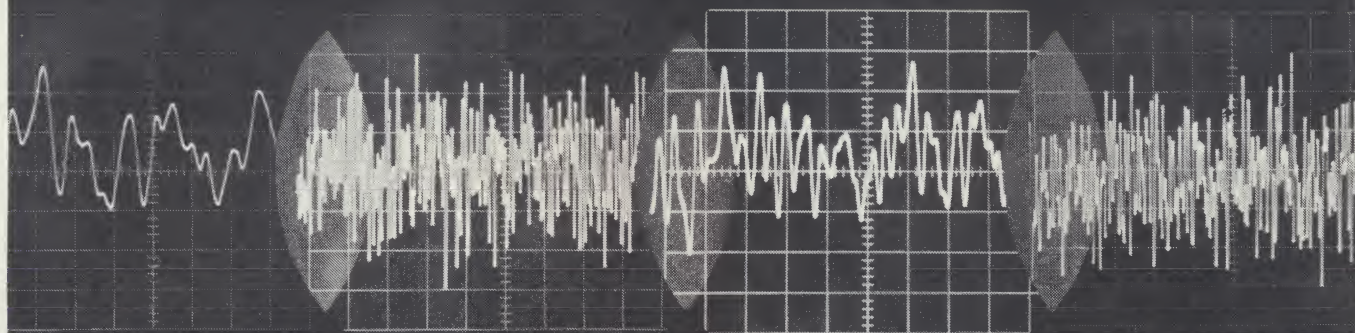


Fig. 13. (A) Voltage-time plot of random variations. (B) Power spectral density curve shows relative power distribution vs frequency.





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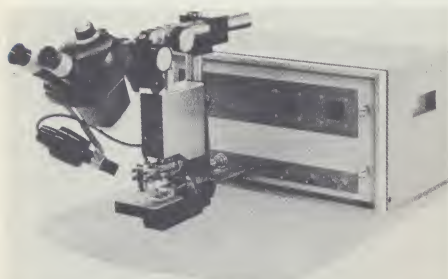
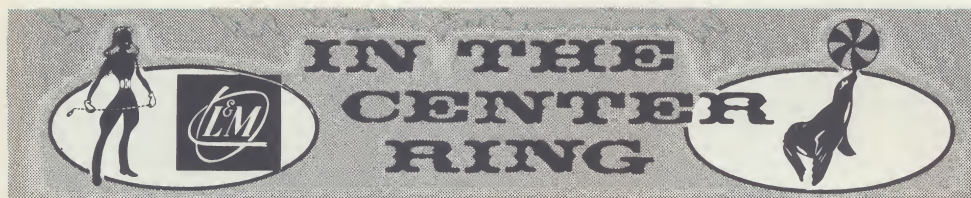
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For desoldering of a defective or misplaced IC, the heating cycle can be extended and the head raised while the solder is molten. The vacuum gently lifts the device without damage to leads or printed circuit pads.

The MLS/AL System includes the MCW-550 Constant Voltage Power Supply, the VTA-67 All Lead Reflow Soldering Head, a Bausch & Lomb Optical Aid Assembly and necessary accessories for operating the system.

WIRECENTER

The all new design **Hughes Aircraft Company** Wirecenter is now offered for wire laying and terminating applications. This advance design includes an integrated numerical control system which includes many new features. The new design and added features which are not available in other equipments result from electronic production experience with this equipment over a period of three years.

Several of the features of the Wirecenter include Trucite a teflon impregnated metal which makes it unnecessary to ever require oiling or lubrication of the "ways". The **Hughes** Wirecenter includes a countdown register making for a standard capability of the programming from 0.001" to 39.999" per block. The worktable can be vertically adjusted over a range of 20" and is designed to support chassis as

heavy as 400 lbs.

The programmed data display includes six digits and may be used either in combinations or separately for many different purposes. For example, two digits may be utilized for designating wire length. Another digit may be utilized for sequence numbering. Several digits may be used indicating the number of an individual wire. The sizes of the wire to be used may be indicated to the operator. Colored wire for a specific connection may be designated to the operator. Other functions such as changing aids twisted pair terminals, etc., can be displayed as cues to the operator.



A staff of highly trained **Hughes** field service representatives are located throughout the United States and the World to assist users of the **Hughes** Wirecenter. Factory trained service engineers are available for instruction and training programs. **Hughes** provides a complete and well-rounded program developed for operating and maintaining Wirecenter to assure achieving maximum operating efficiency for the user as well as maximum production quality.

SQUARE CUT CUTTER

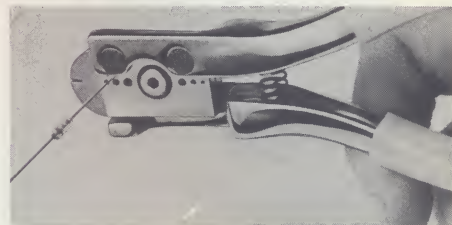
The **Henes Manufacturing Company** has perfected a unique tool that will cut "absolutely" flat, burr-free ends on wire, metal ribbon, or small-diameter metal tubing.

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The smooth, flat-cut ends provided by the tool eliminate the need for secondary finishing on wires that are to be butt-welded or soldered.



The modular blade assembly of the **Henes** Square-Kut tool is fabricated to diemaking standards from hardened tool steel that is specially ground and lapped.

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The Model 421 output has a true gaussian amplitude distribution and a spectral density independent of frequency (white noise).

Noise output is calibrated in spectral density (microvolts in a 1Hz bandwidth), which is the accepted standard of the electronics industry.

SPECIFICATIONS

Output Voltage/Spectral Density:

0.1 to 300 microvolts into 75 ohms (1.34 volts RMS for full bandwidth) Continuously monitored, linear meter scale. Flat from 10KHz to 12.5MHz: -3 db at 20MHz $\pm$ 0.5 db.

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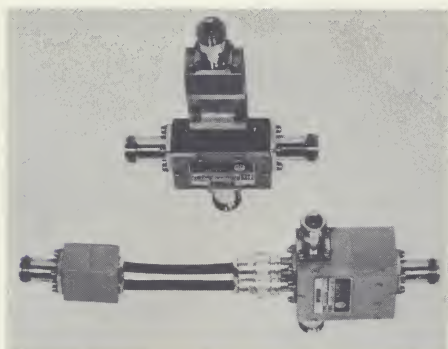
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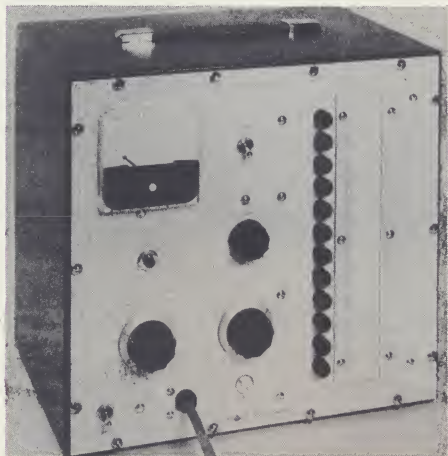
STD-810A. These hybrids cover approximately octave bandwidths ranging from 20 to 10,500 GHz and feature very high isolation between sum and difference ports ranging between 35 and 60 db depending on the model.

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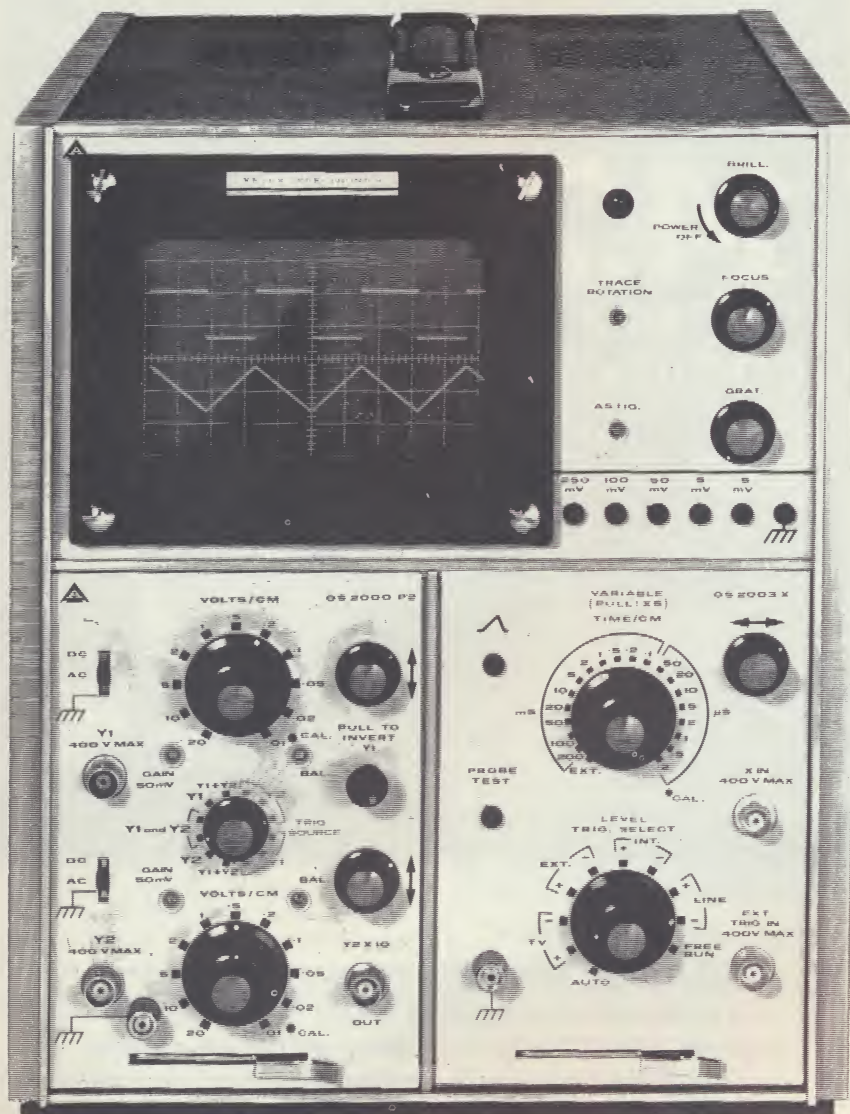
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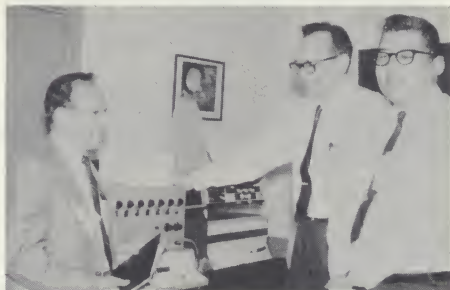
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"Ruby" Rubenstein of L & M, L. I., demonstrating the CDC Hi Speed I.C. Tester with Ray Szmerda and Frank Anaya, both of ITT.



Len Blakely of L & M, N. Y., lecturing Seymour Levine of ITT on the application of Micom WOW and Flutter Meter.



Demonstrating the Hughes Microcircuit Ball Bonder to Al Goldstein (seated) at LEL, Copiague. Standing from left to right are "Ruby" Rubenstein of L & M, L. I.; Mike Fukuda of LEL, Marty Silver, L & M, N. J.; and Frank Oliva of LEL.



Bill Drobile, L & M, Andalusia, demonstrating the Henes Water Welder to Jack Johnston of the DuPont Co.

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VOLUME 7 NO. 4



This month's Ringmaster is **Robert S. Kennedy**, Marketing Manager, of the **James G. Biddle Company**. Bob joined Biddle in 1962 as Manager of Product Planning, transferring to Marketing Manager the following year. Prior to **Biddle**, Bob spent 14 years with the **General Electric Company**, leaving from the position of Sales Manager for the distribution products of the **High Voltage Switchgear Division** in Philadelphia.

Bob graduated from the **U.S. Naval Academy** in 1945, spending the two following years on destroyer duty supplemented by two years on submarine duty during the **Korean** crisis.

When **Biddle** moved to their new Plymouth Meeting Plant in suburban Philadelphia, Bob followed them and now lives on a small farm in North Wales along with his wife;



ROBERT S. KENNEDY

Mary, three children, seven cats (at last count), two dogs and two horses. Hobbies are tennis, golf and plant (farm) maintenance.

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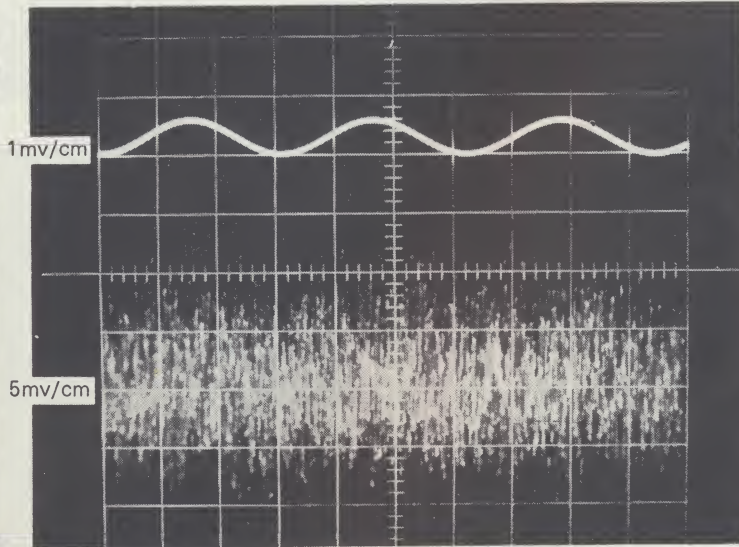
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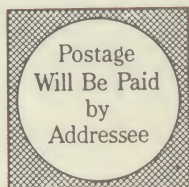
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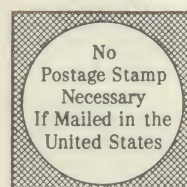
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MARCONI INSTRUMENTS

- ☐ Signal Generators, FM/AM/Sweep/Transistorized
☐ FM Deviation Meters ☐ Bridges and Q-Meters
☐ Voltmeters ☐ Receivers, AM/FM/SSB
☐ Intermodulation and Base Band Test Gear
☐ Programmable Attenuator ☐ Coaxial Switch

MICOM, INC.

- ☐ WOW and Flutter Meters ☐ Statistical Voltmeter

QUAN-TECH LABORATORIES, INC.

- ☐ Wave Analyzers and Noise Generators
☐ Transistor, Diode & Resistor Noise Measuring Sets
☐ Transistorized Plug-In Amplifiers

TROMPETER ELECTRONICS, INC.

- ☐ Coaxial Plugs ☐ Cable and Patch Panels
☐ Video and Data Switch Systems

☐ Shall we contact you about an In-plant show?

☐ Other



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Mr. T. Nelson
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